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(54) RESISTANCE WELDING ELECTRODE

(71) We, REYNOLDS METALS COMPANY, a Corporation organized and existing under the laws of the State of Delaware, United States of America, of 6601 W. Broad Street, Richmond, Virginia 23261, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:–

This invention relates to resistance welding and, more particularly, to that area of the art wherein two work-contacting electrodes are utilized, including such various forms as spot welding and seam, stitch and roller welding, and projection welding.

In resistance welding generally, the faying surfaces of the electrically conducting members to be joined are superimposed under pressure. The fusion or coalescence of these surfaces is accomplished by flowing an electric current through a circuit of which the work is a part. In the form of resistance welding of specific concern herein, electrical contact with the work is made, and the loading thereof is typically provided, by means of two opposed electrodes.

As is well appreciated in the art, substantial problems are often encountered on account of surface contamination of the work. Such is especially the case where the work is of an aluminious material, the same typically being quite prone to oxidation on exposure.

Where the outer exposed surfaces of the work are oxidized or otherwise contaminated, the number of acceptable welds obtainable between electrode dressing or replacement can be expected to decrease considerably. Consequently, much attention has heretofore been directed toward providing a cleaning of the work prior to welding.

Apart from the problems associated with contamination, the art has also been concerned about certain inconveniences caused by the tendency of the metal of the work to diffuse into the work-contacting surface portion of a conventional copper or copper-base alloy electrode. One effort to overcome such inconveniences was proposed in U. S. Patent No. 3,665,145 by H. J. Engle. According to the Engle patent, a conventional electrode can be improved through forming a work-contacting layer thereon by coating the appropriate surface portion of the electrode with a material selected from the group consisting of nickel, beryllium, cobalt, iron and high melting point alloys of the foregoing, which are defined as alloys of melting point at least equal to that of copper.

While the teachings contained in the Engel patent are alleged to be of substantial importance in connection with the inconveniences caused by diffusion, experiments have shown that they are of little consequence in respect of the distinct set of problems brought on by contamination. In other words, mere obedience to the principles set forth in the Engel patent has not proved to be an effective substitute for the removal of contamination from the work.

What has now been discovered is that a shot-peening of the appropriate surface portion of a conventional electrode reacts synergically with the subsequent application of a coating thereto as taught by Engel, the result being an improved electrode having a substantially greater comparative useful life when subjected to the welding of contaminated work.

Without wishing to become bound thereby, it is theorized that this result is achieved for two reasons. First, the shot-peening is believed to work-harden the affected electrode surface and thereby make it more resistant to deformation which is known to have an adverse impact on weld quality. Such deformation, it is believed, is typically advanced by contamination due to the annealing effect of the resultant increase of localized heating. Secondly, it

is conjectured that the shot-peening provides the affected electrode with multitudinous indentations, thus leaving a plurality of relatively sharp ridges intermediate to adjacent indentations. Such ridges, it is believed, may substantially pierce the contamination layer on the work so as to effectively avoid its ramifications. As for the role played by the coating, no explanation is guessed at outside of the teachings supplied by Engel.

The invention also includes an embodiment which has been found especially suited for the welding of aluminious materials. Specifically, the embodiment comprises a shot-peened body member in combination with a coating of nickel, and more particularly, a coating of nickel having a dull finish such as the kind achievable by electroplating in the absence of brightening agents.

In respect of the foregoing embodiment, it has been discovered that the thickness of the coating has a substantial effect on the results to be obtained. Accordingly, the presently preferred range for the thickness of the nickel coating for welding aluminous materials is from about 0.00001 to about 0.001 inches; and more particularly, a thickness of about 0.00007 inches is presently desired.

Again in respect of the foregoing embodiment, it has further been discovered that when shot-peening is used to condition the body member, of some significance is the shape, size, material and momentum of the shot. Accordingly, of present preference is substantially spherical shot of aluminium oxide, having an average size corresponding to about 54 U. S. Standard mesh, when blasted by means of an air pressure differential of about 65 psi.

Other details, uses and advantages of the invention will become more apparent as the invention is hereinafter described in detail and particularly pointed out in the claims.

As required, detailed embodiments of the invention are herein disclosed. However, it is to be understood that these embodiments are merely exemplary and therefore are not to be construed as limiting. For example, while an improved electrode for the welding of aluminous materials is described in particular, the invention may yet embrace other forms as should be obvious from the disclosure as a whole.

Referring now to the body member of the resistance welding electrode of this invention, it is contemplated that the various principles under discussion are generally applicable to conventional shapes such as are known in the arts of spot welding and seam, stitch and roller welding. The body member will be of copper or a copper-base alloy, and the surface portion of the body member which will be work-proximate in use is conditioned by shot-peening the body member surface portion prior to the application of the coating thereto.

As has been mentioned the invention requires a coating in combination with the conditioned body member, the coating being applied to define an outer work-contacting surface of the electrode. The suitable materials for the coating are nickel, berylium, cobalt, iron and high melting point alloys thereof, and can be applied by any known technique, such as it taught in the disclosure of Engel.

Where the invention is to be used for welding aluminious materials, it is presently preferred that the coating be of nickel. Here electroplating with a standard Watts bath has proved to be an ideal coating method. Moreover, it should be emphasized that the best results have been realized when such additives as brightening and leveling agents have been omitted from the bath so as to produce a nickel coating having a dull finish.

For more specific details of an exemplary embodiment of the invention together with the various advantages thereof, reference is now made to the following examples:

EXAMPLE I

In the experiments of this example, sheets of 0.040 inch thick 2036-T4 mill finished aluminium sheet were spot welded. No attempt was made to remove oxide from or otherwise clean the sheet prior to welding.

The machine used was a 100 KVA air-operated press-type spot welder using Sciaky synchronous controls, and water cooled electrodes. The welding circuit utilized 60 Hz 440 volt mains with secondary rectification. A single-squeeze cycle was used in all tests.

Essentially the experiments were run by subjecting a given set of electrodes to successive spot welding operations until an appreciable decline in weld quality was noticed. This point was reached when less than 75% of 100 consecutive welds produced a full-height nugget on peeling apart the sheets.

In the basic experiment, Class I, 5/8 inch D, 3 inch R tip, copper electrodes were each shot-peened and given a 0.00007 inch coating of dull nickel.

Shot-peening was carried out using a Trinco-Dryblast Master Model 48 bead blaster manufactured by Trinity Tool Co., 25140 Easy Street, Warren, Michigan. The blaster was operated with an air line pressure of about 65 psi and used Trin-Blast 54 U. S. Standard mesh aluminium oxide beads, also manufactured by Trinity Tool Co.

Subsequently, the shot-peened electrodes were electroplated with nickel pursuant to an approximate two minute immersion in a Watts bath, the composition and operational parameters of which are summarized as follows:

Composition	
Nickel Sulfate ($NiSO_4 \cdot 6H20$)	32 Oz/gal.
Nickel Chloride ($NiCl_2 \cdot 6H20$)	6 Oz/gal.
Boric Acid (H_3BO_3)	4 Oz/gal.

Operational Parameters	
Temperature	135°F
pH	5.2
Current Density	30 amp/ft^2

In the course of the basic experiment some 2000 successful welds were obtained prior to the concluding decline in weld quality.

As a first control measure, the experiment was repeated under approximately identical conditions except that the electrodes were neither shot-peened nor coated. Here only about 750 welds were obtained.

A second control measure was taken repeating the conditions of the basic experiment except that the electrodes were not coated. In that case only about 900 welds were obtained.

Finally, the basic experiment was repeated except that the electrodes were not shot-peened. In that run the number of successful welds was only about 750.

EXAMPLE 2

The subject of this example is an effort made to ascertain the criticality of the thickness of the nickel coating. Accordingly, the basic experiment of Example 1 was repeated except that the plating thickness was varied at 0.0015, 0.0010, 0.00020, 0.00010, 0.00004 and 0.00002 inches. The number of successful welds respectively achieved at each thickness were 20, 100, 1600, 1500, 760 and 1000. Quite clearly the 2000 welds in Example 1 for a 0.00007 inch thickness represent the best result in comparison.

EXAMPLE 3

In the experiment of this example the purpose was to establish the importance of the type of nickel finish. Thus the basic experiment of Example 1 was repeated except that a brightening agent was added to the bath. In that run, the operation had to be halted after 40 welds on account of metal plugs being pulled out of the work by the electrodes.

EXAMPLE 4

The purpose of the tests in this example was to determine the significance of the size of shot utilized for shot-peening. Again, the basic experiment of Example 1 was repeated except that 100, 36 and 24 U. S. Standard mesh aluminium oxide beads were all used. Although about 2000 welds were obtained in each instance, it was found that the electrodes showed signs of various degrees of pitting, a problem which was not encountered in the course of the basic experiment.

While various exemplary embodiments of the invention as well as methods of practicing the same have been described, it is to be understood that the invention may be still otherwise embodied and practiced within the scope of the following claims.

WHAT WE CLAIM IS:–

1. A resistance welding electrode having a copper or copper-base alloy body member and a work-contacting surface coating on a surface portion of the body member, the surface portion having a shot-peened surface and the coating being composed of nickel, berylium, colbalt, iron or a high melting point alloy of the foregoing (as hereinbefore defined).
2. An electrode according to Claim 1 wherein the coating is of nickel.
3. An electrode according to Claim 1 or 2, wherein the coating has a dull finish.
4. An electrode according to Claim 2 or 3 wherein the thickness of the coating is within the range of 0.00001 to 0.001 inches.
5. An electrode according to Claim 4 wherein the thickness of the coating is about 0.00007 inches.
6. A method of forming a work-contacting layer on a surface portion of a copper or copper-base alloy body member of a resistance welding electrode, which comprises shot-peening the surface portion of said body member, and coating the shot-peened surface portion with nickel, berylium, colbalt, iron or a high melting point alloy of the foregoing (as hereinbefore defined).
7. A method according to Claim 6 wherein the said surface portion is coated with nickel.
8. A method according to Claim 6 wherein the said surface portion is coated with nickel

having a dull finish.

9. A method according to Claim 6 wherein the said surface portion is coated with nickel to a thickness within the range of 0.00001 to 0.001 inches.

10. A method according to Claim 9 wherein the said surface portion is shot-peened by substantially spherical shot of aluminium oxide having an average size corresponding to about 54 mesh (U. S. Standard), blasted by means of an air pressure differential of about 65 psi.

11. A method according to any of Claims 6 to 10 wherein the said surface portion is coated with nickel to a thickness of about 0.00007 inches.

12. A resistance welding electrode having a work-contacting layer formed in accordance with a method according to any of Claims 6 to 11.

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